



MIT International Center for Air Transportation

Human Factors Considerations in Future Oceanic Air Traffic Control System Architecture

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Future Oceanic Air Traffic Control System Architecture Project

❑ Academic:

- University of Iceland and MIT

❑ Government:

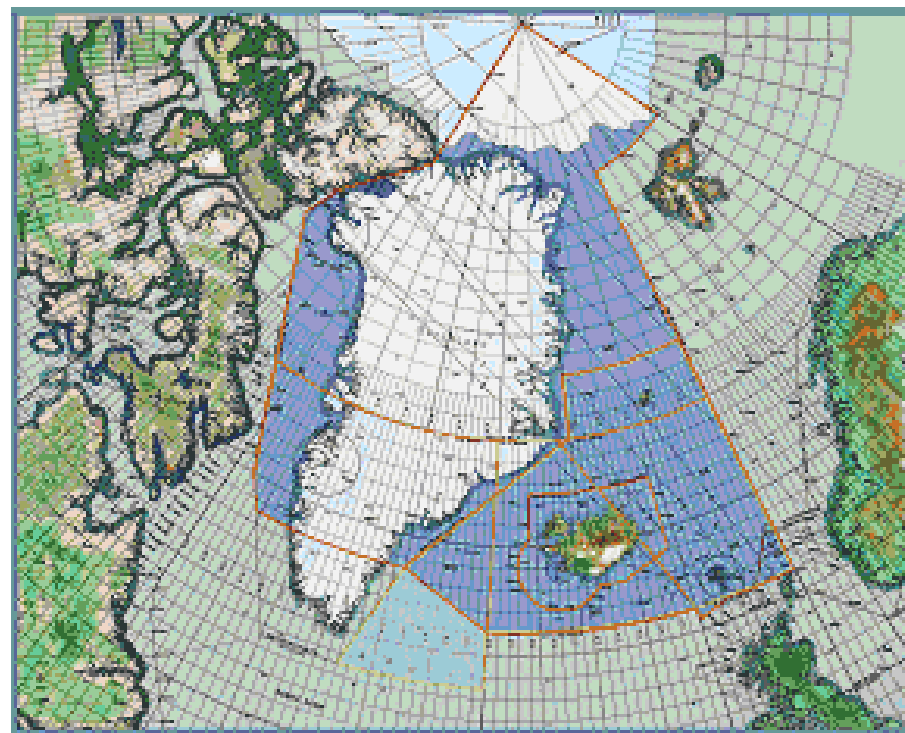
- CAA of Iceland and FAA



UNIVERSITY OF ICELAND



➤ Research program
to evaluate Human
Factors in Future
Oceanic Air Trans-
portation Systems
Architecture



Motivation

- ❑ Increased traffic and emphasis on safety in the oceanic environment demand:
 - Reduced separation minima
 - More efficient routing
- ❑ Oceanic air traffic control systems and processes are evolving and new technologies (e.g. ADS), integrated information systems, and new procedures will likely be incorporated.
- ❑ This new environment will influence the tasks of the controller and pilot, therefore human factors considerations should be integrated into the design from the beginning

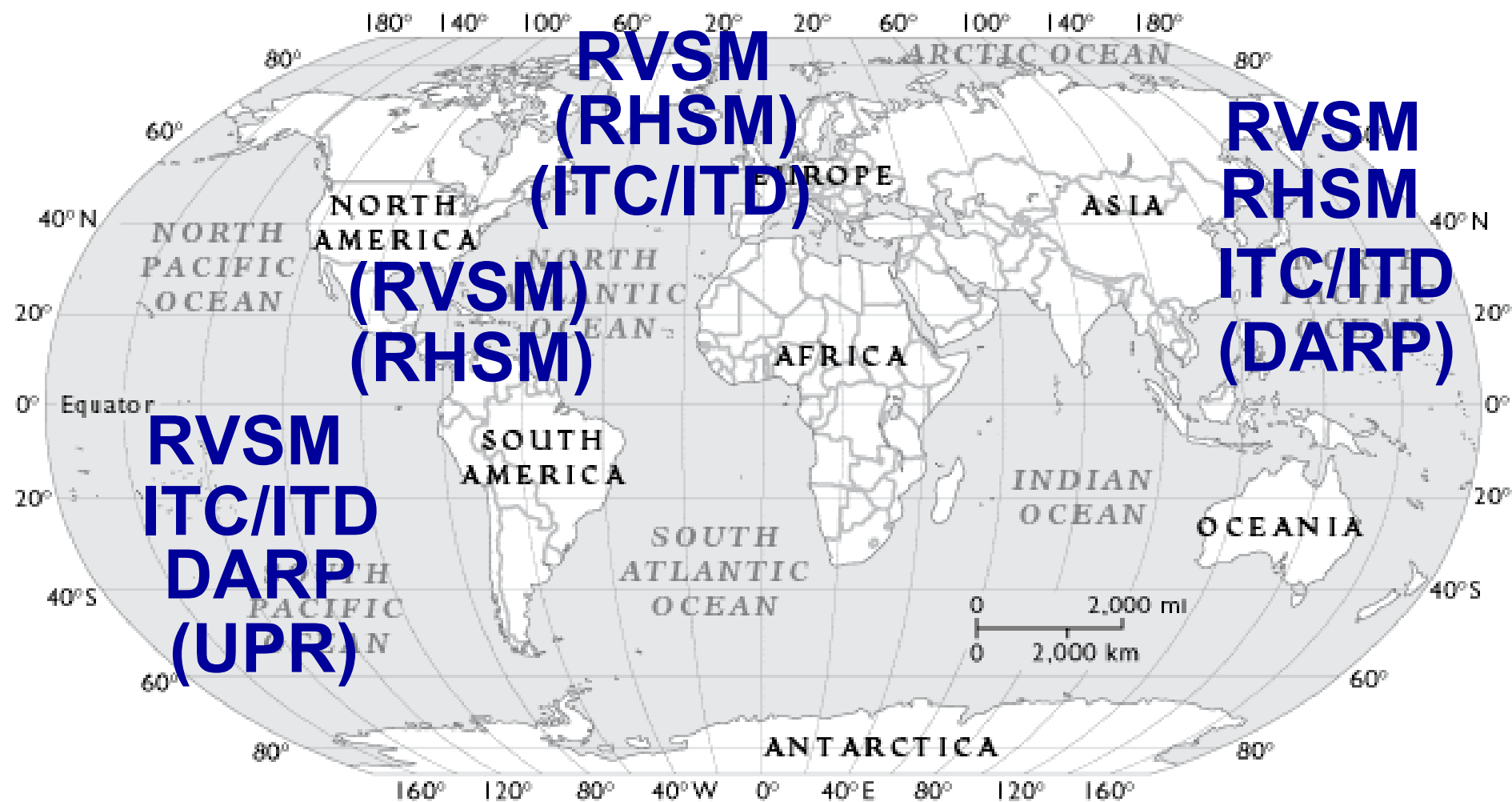
Key Issues

- ❑ What are potential changes in operational **role** of controller and pilot?
- ❑ How will the new oceanic environment influence **workload** under normal and non-normal operations?
- ❑ What are costs and benefits associated with the new oceanic environment in areas such as **situation awareness, training, skill maintenance, and vigilance**?
- ❑ How to **transition from a procedure-based** system to one where the new oceanic environment provides more accurate & frequent aircraft position information?

Tasks

- Phase I (2002-2004) – *Assess human performance impacts of advanced technologies and compare with the ICAA Future Oceanic Air Traffic Control Workstation including the impact of ADS-B*
 - *Task 1 – Analysis of Oceanic ATC to define a concept validation framework for future oceanic operations (using Integrated Human-Centered Systems Approach).*
 - **Task 2** – Field observations of Oceanic ATC operations for familiarization and to support and refine the analysis.
 - **Task 3** – Develop a concept validation strategy for near and far term enhanced oceanic operating environments.
 - **Task 4** – Address human performance issues.
 - **Task 5** – Complete analysis tailored to address the derived higher priority HF issues.
 - **Task 6** – Plan for prototyping and evaluation phases.⁵

THE WORLD



Integrated Human-Centered Systems Approach

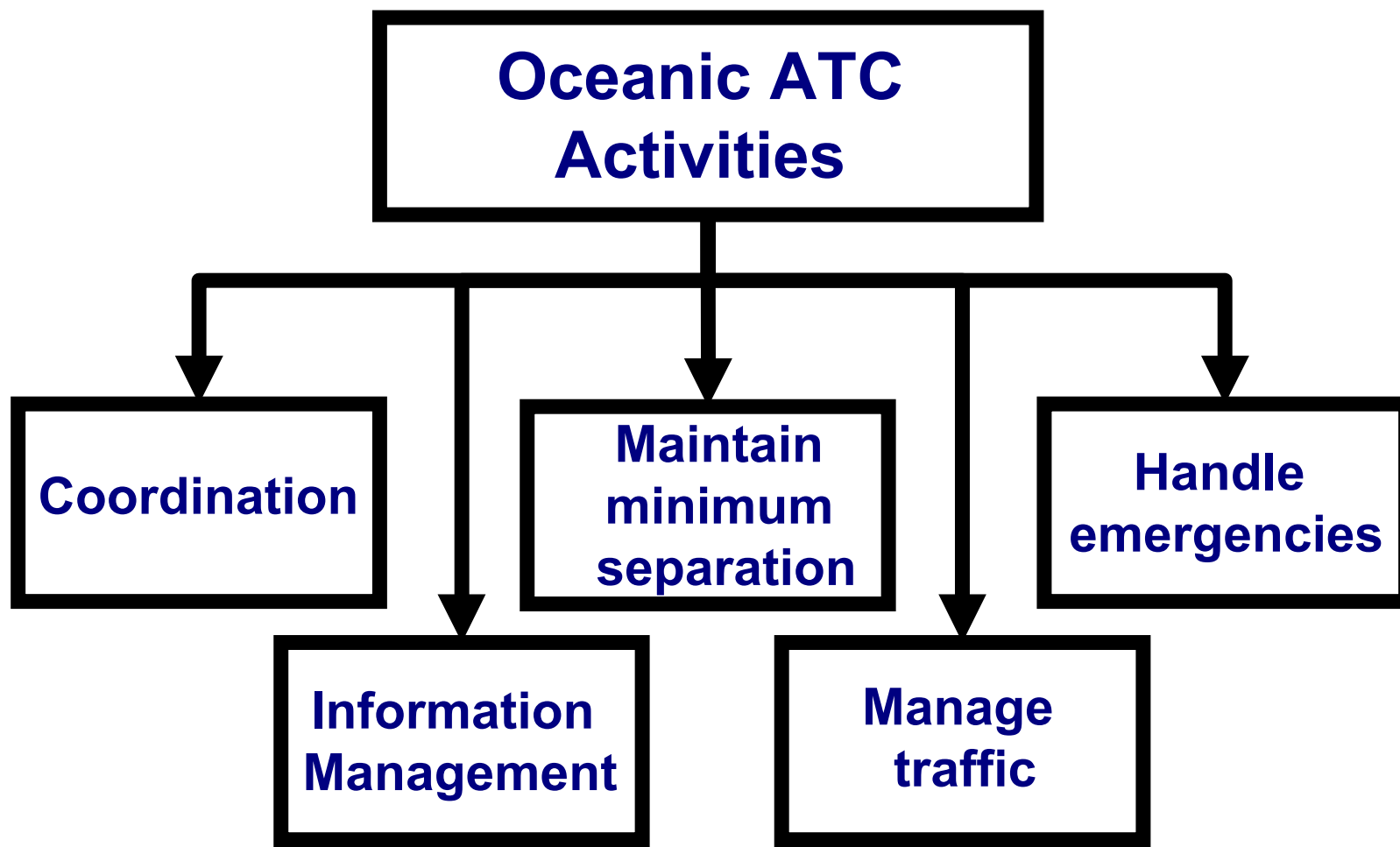
- ❑ An **Integrated Human-Centered Systems Approach** is suggested as the basis for
 - **Evaluation of the effect** of new technology on the current oceanic environment and;
 - **Recommendations** for design of future information systems
- ❑ Human considered a functional (but stochastic) component of a closed-loop information system
- ❑ Identify the interfaces between the human and the system when solving the task.



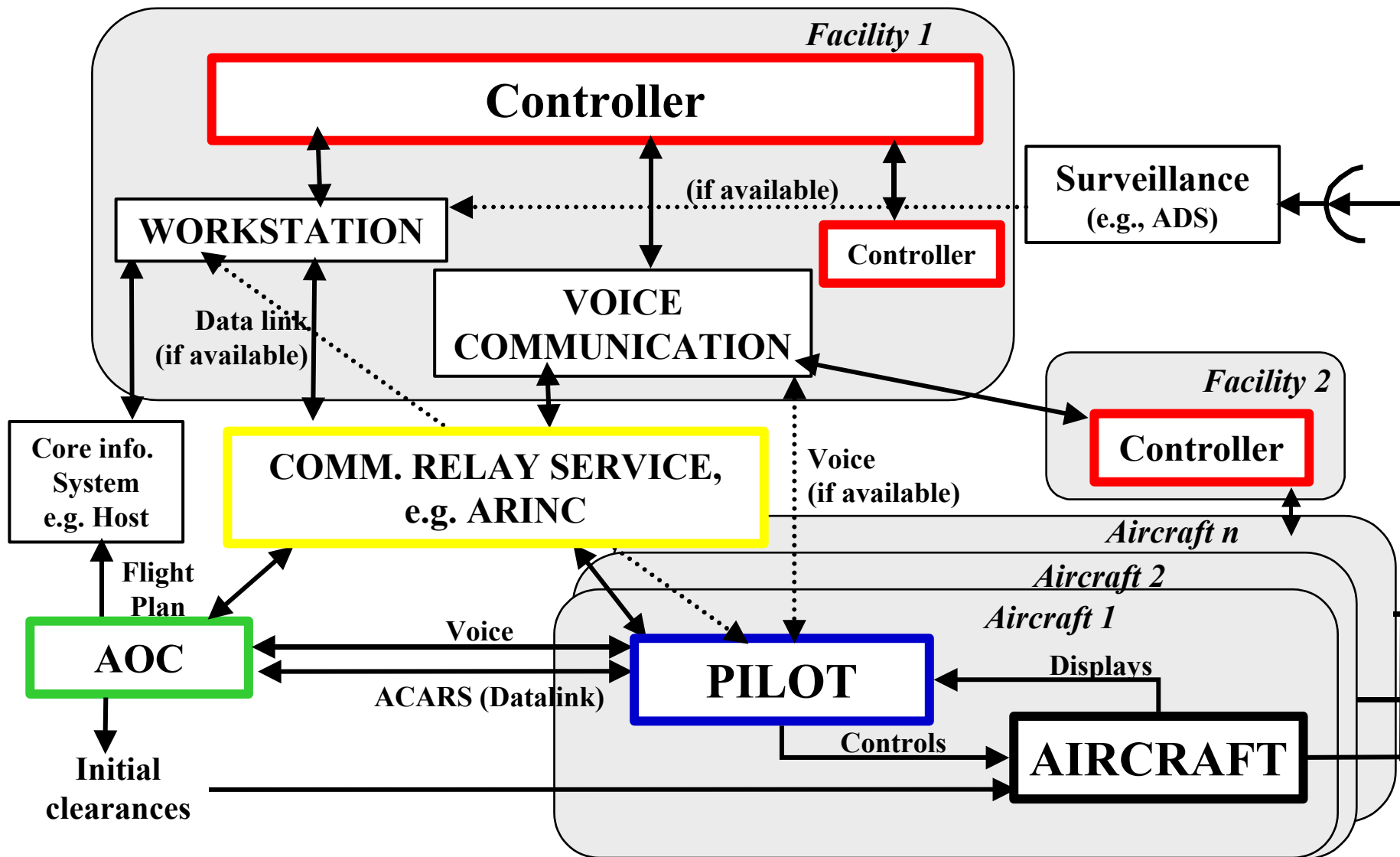
Steps in Integrated Human-Centered Systems Approach

- ❑ Step 1: Model the System & Operator(s) as a closed-loop feedback process
- ❑ Step 2: Determine information that the Operator requires to perform the task
- ❑ Step 3: Use information requirements to determine Display/Automation specifications
- ❑ Step 4: Develop prototype system
- ❑ Step 5: Perform simulation evaluations
- ❑ Step 6: Perform integrated system testing
- ❑ Step 7: Perform system evaluation

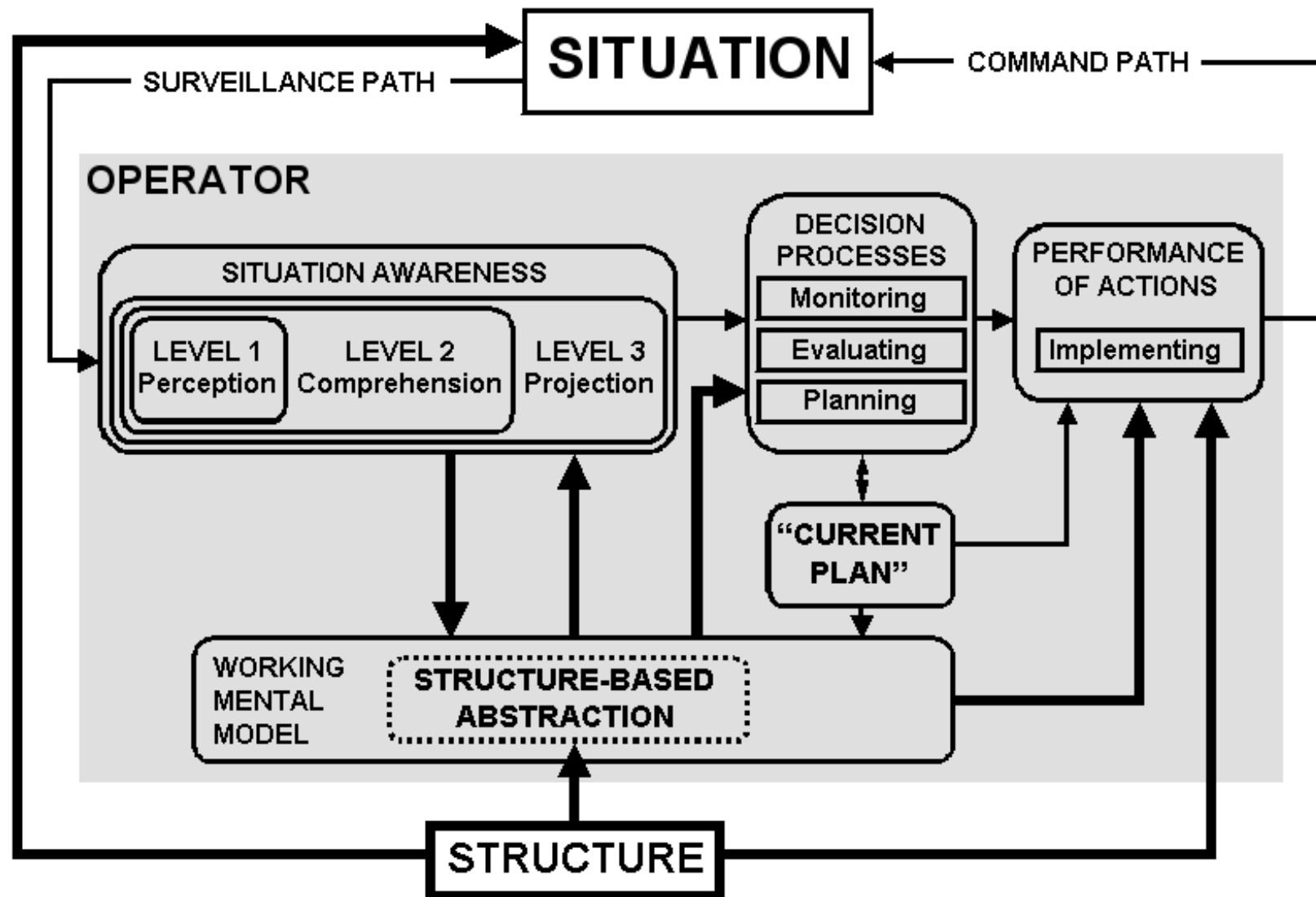
Oceanic ATC Activities



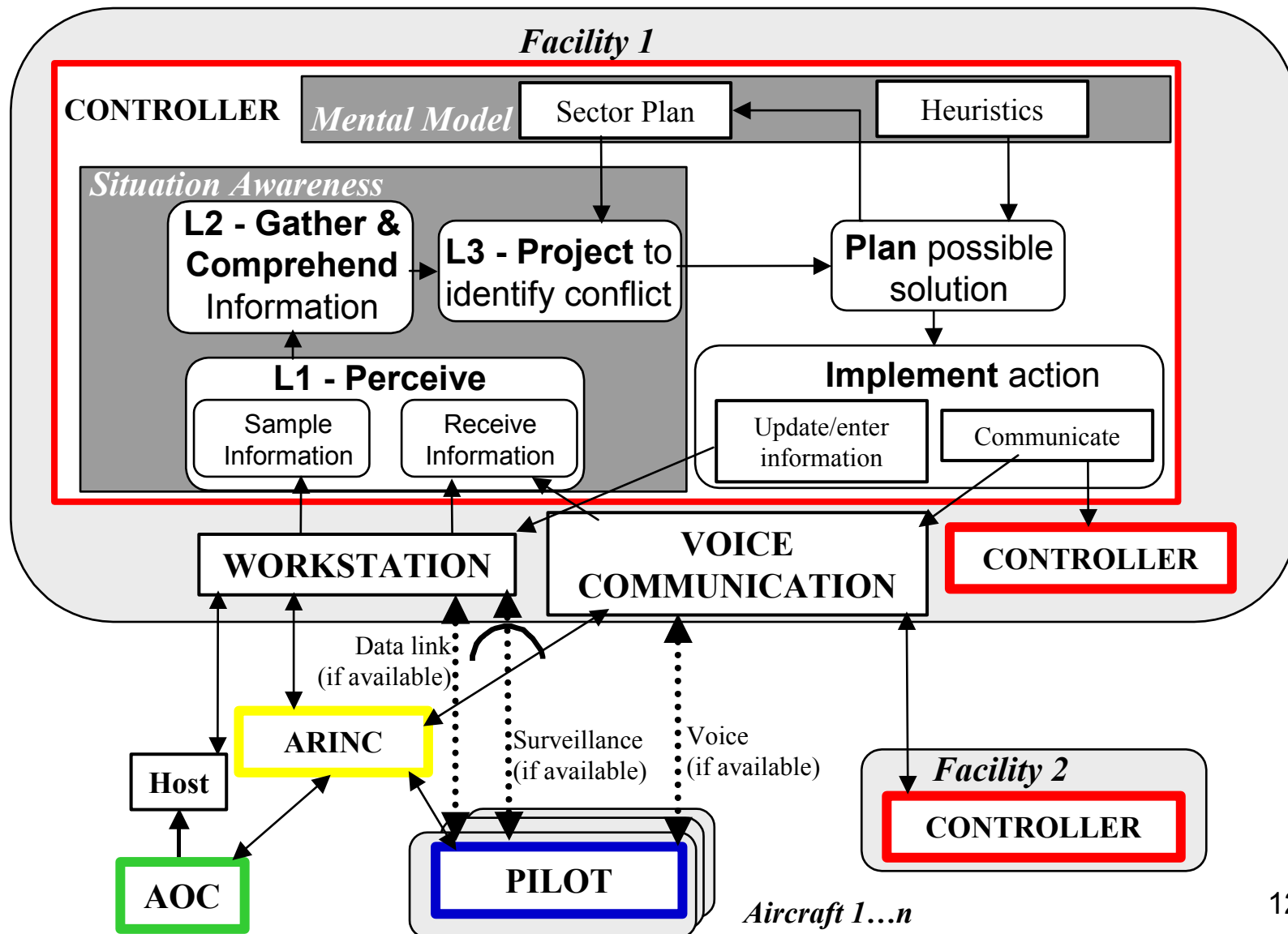
Current Controller-centered Control Loop Model



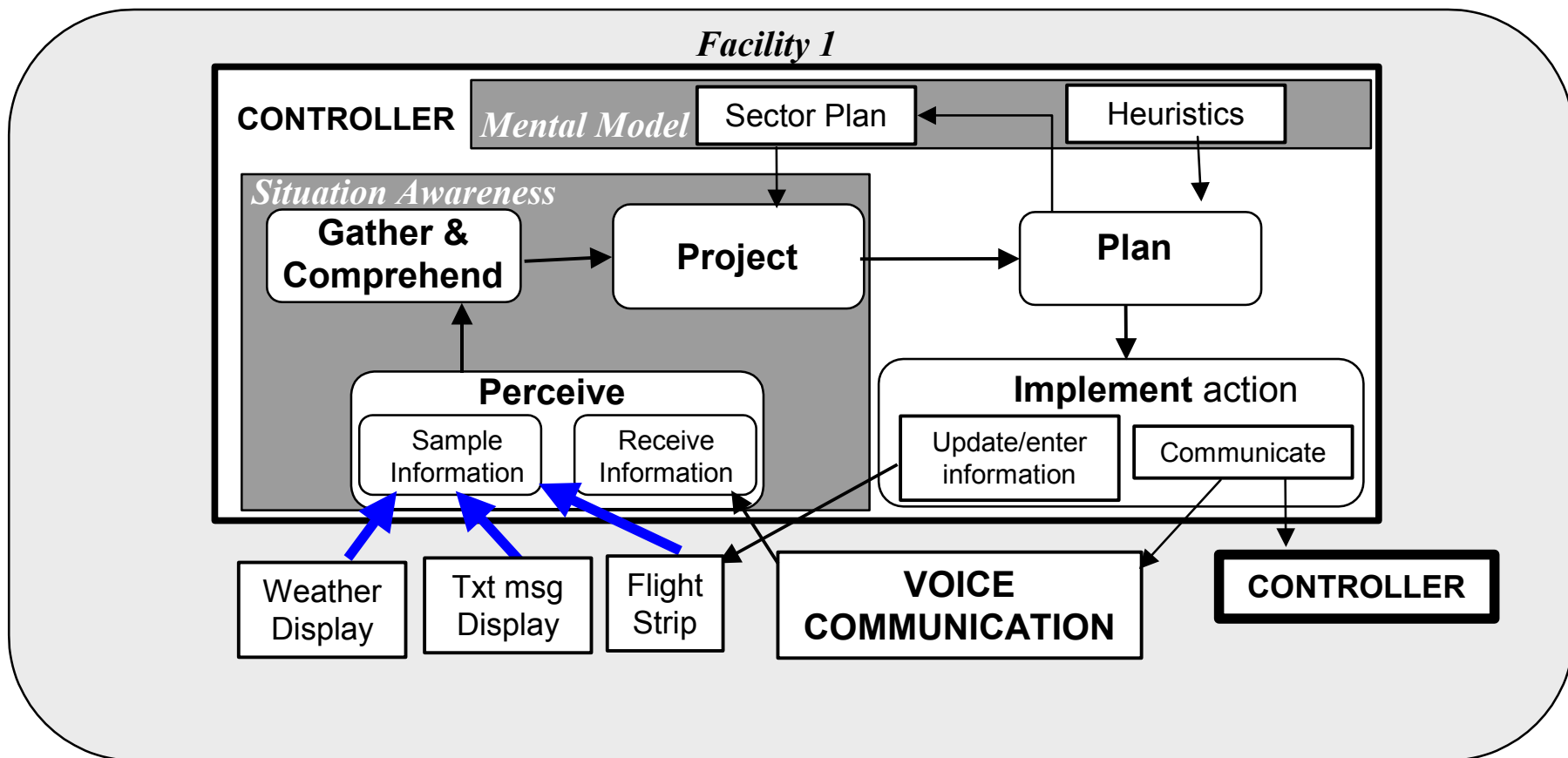
Influence of Structure on Complexity Management



Current Controller Cognitive Model

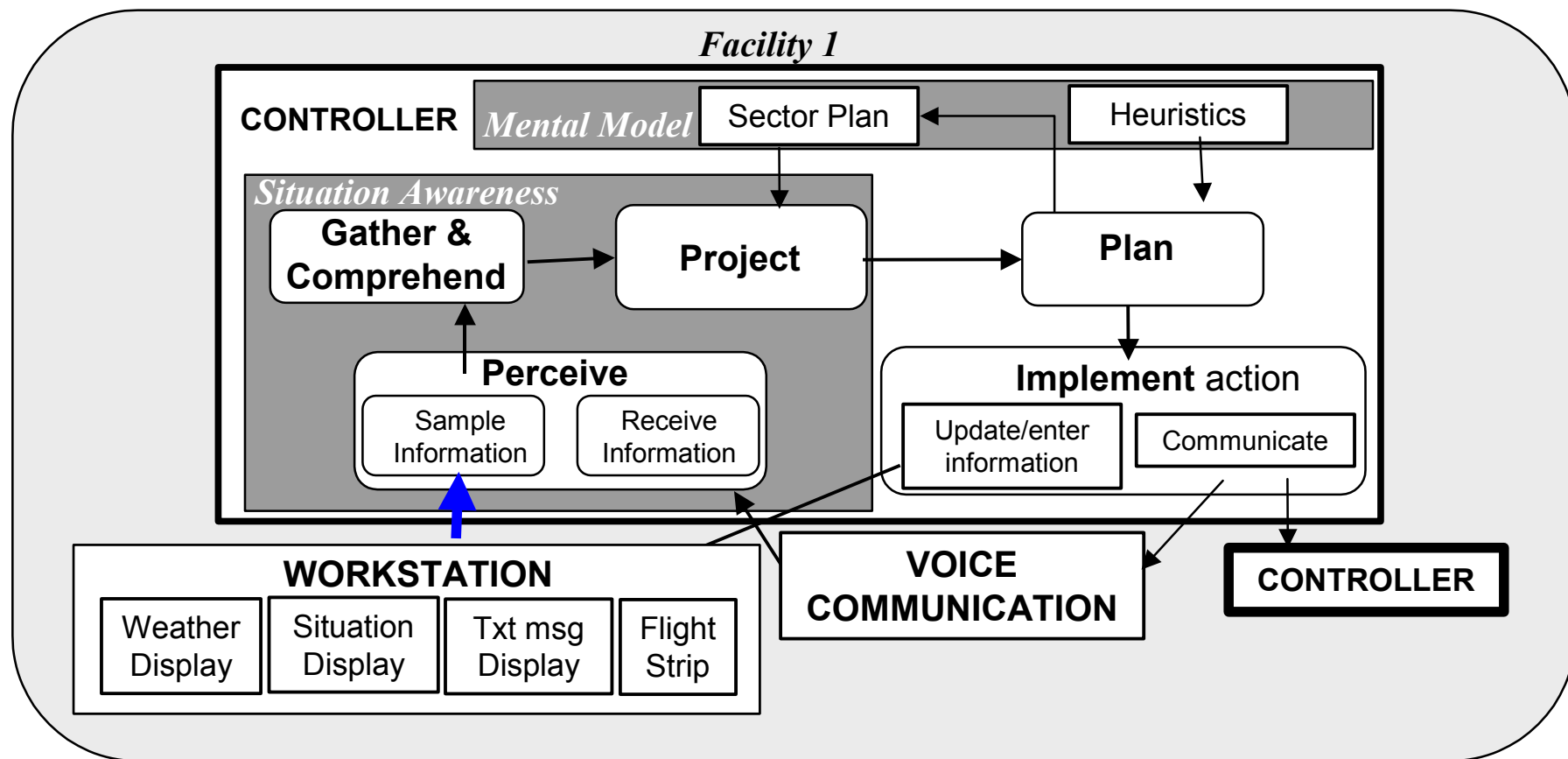


□ Information displayed to the ATC



Current situation

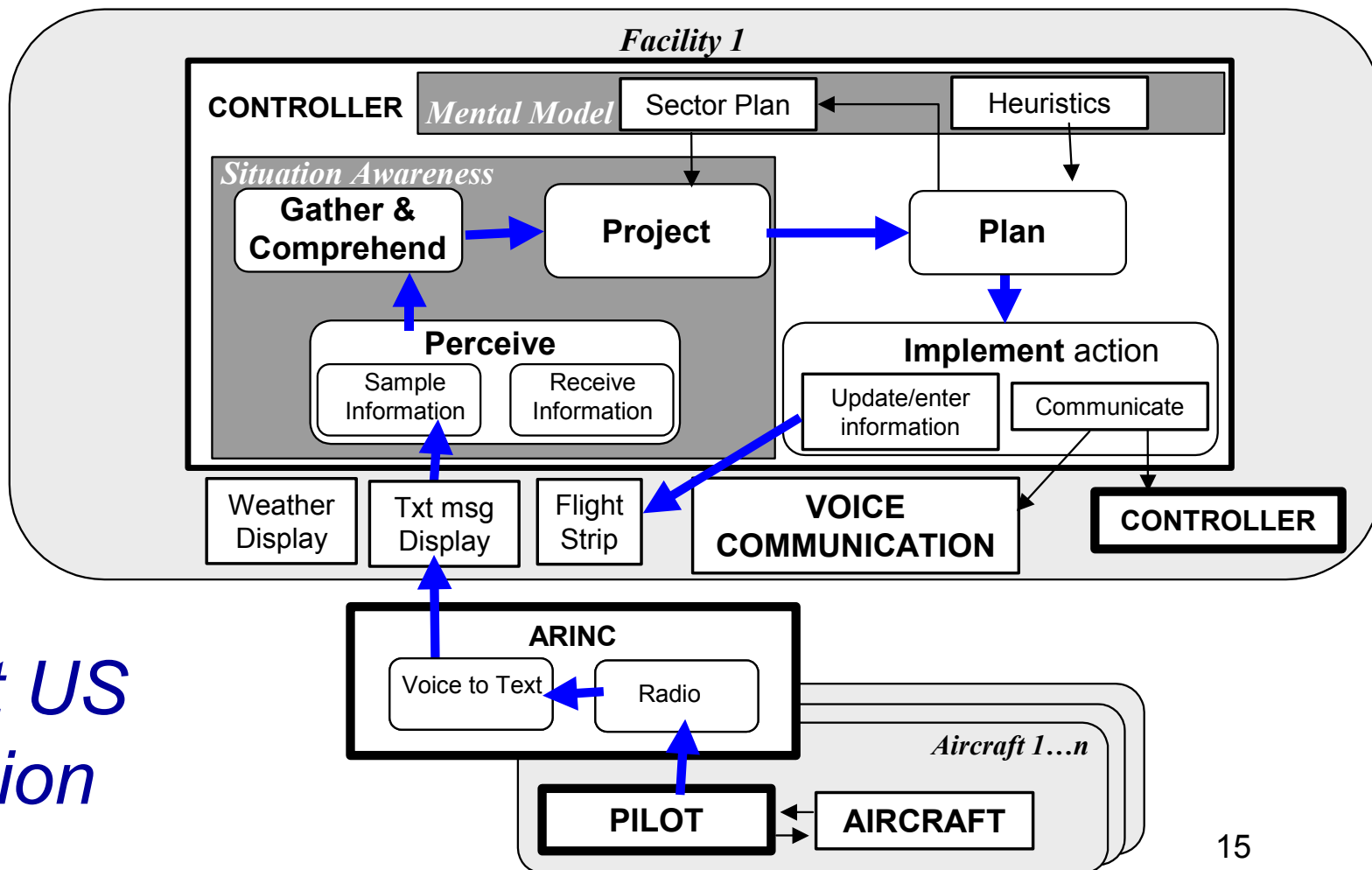
□ Information displayed to the ATC



Future situation

Current & Future Technologies – Communication System

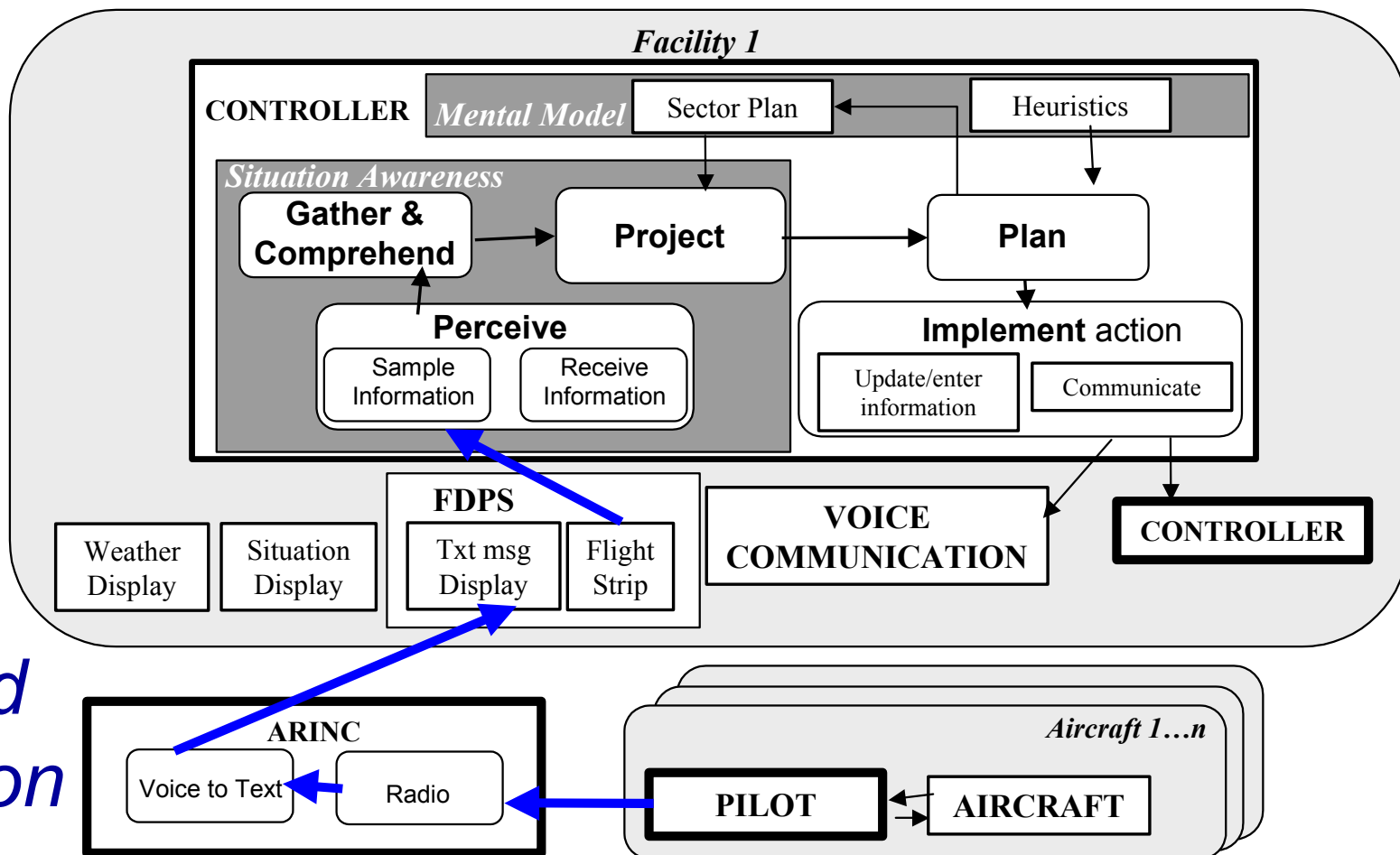
□ Information from the aircraft to the controller



Current US situation

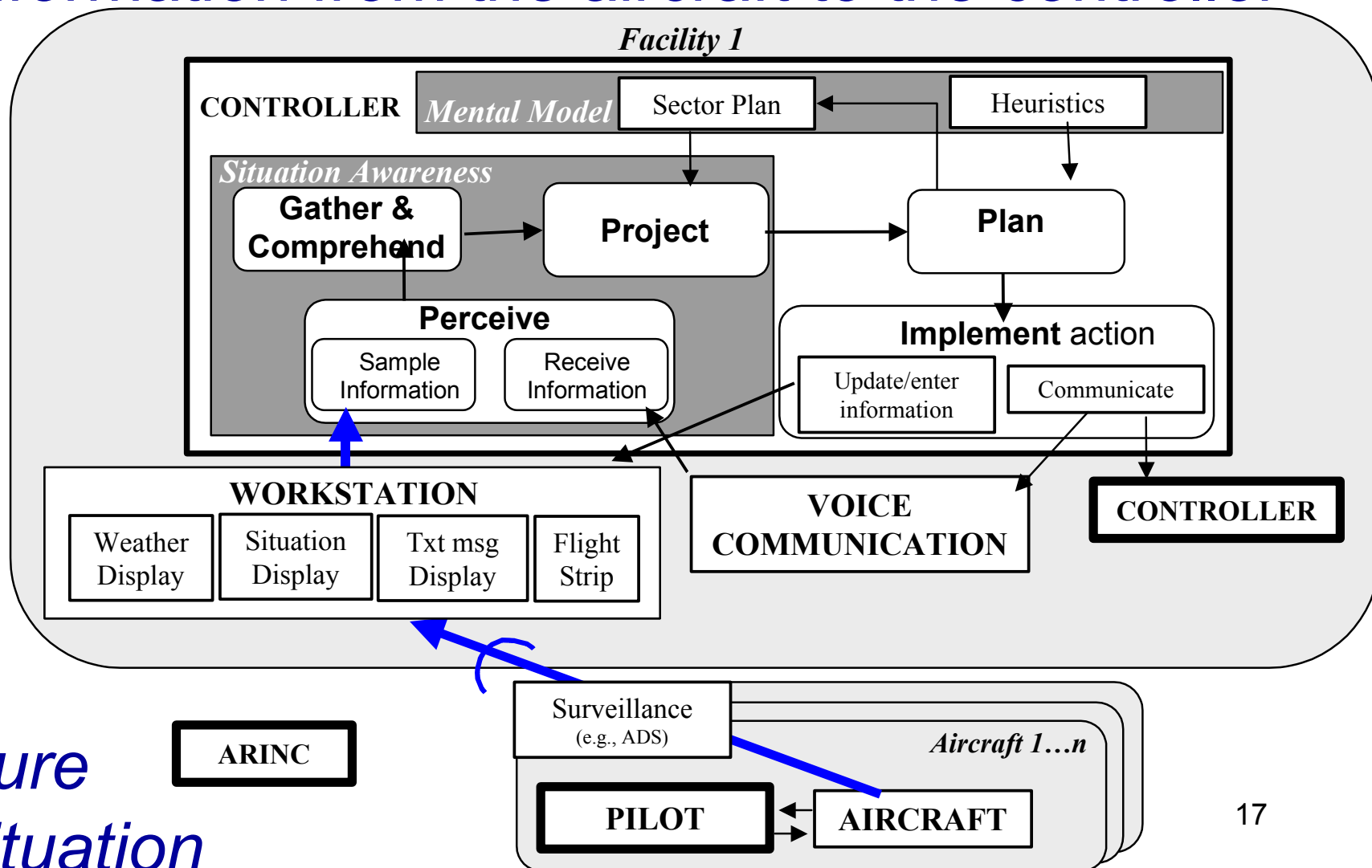
Current & Future Technologies – Communication System

□ Information from the aircraft to the controller



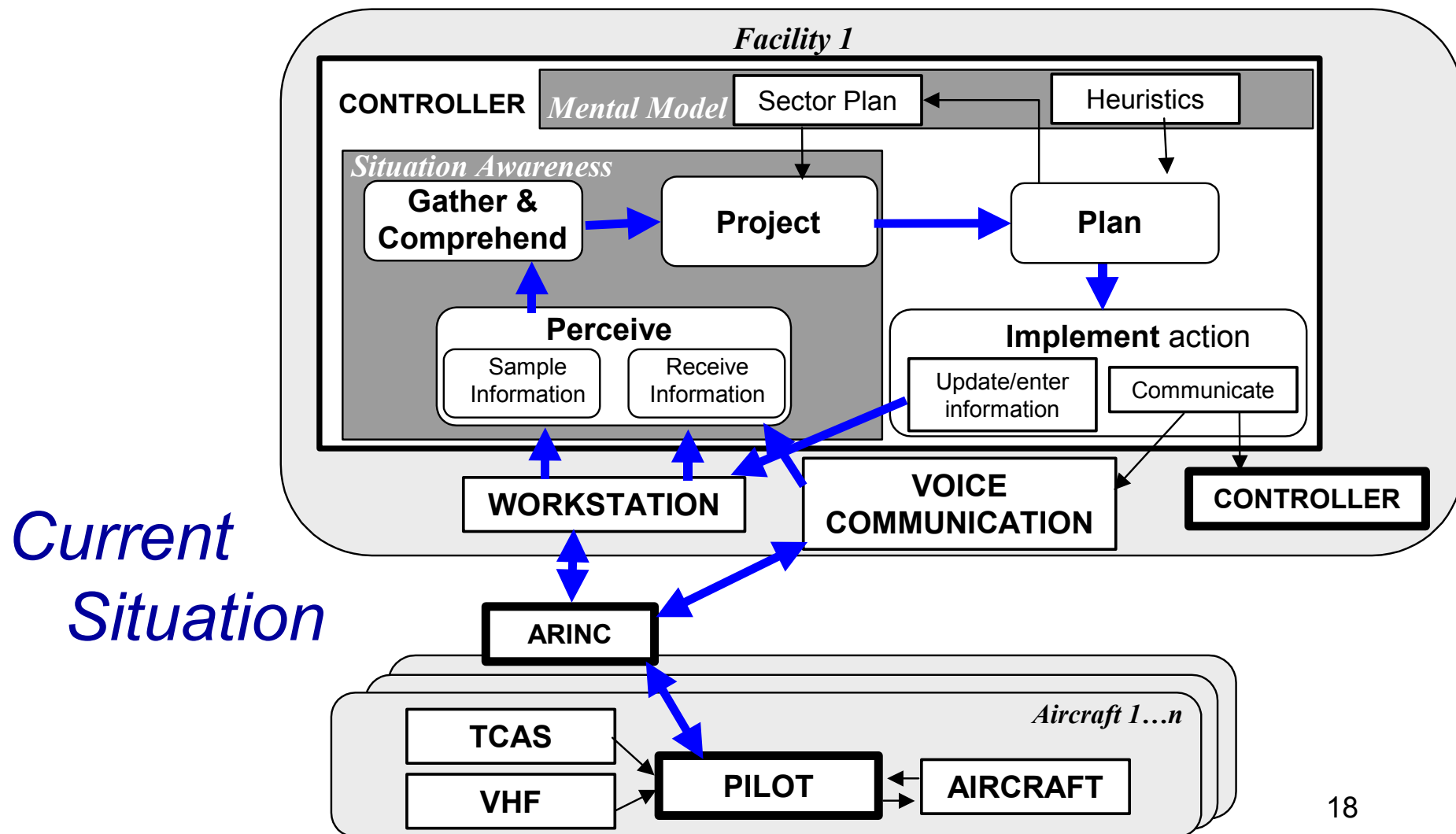
Current & Future Technologies – Communication System

□ Information from the aircraft to the controller



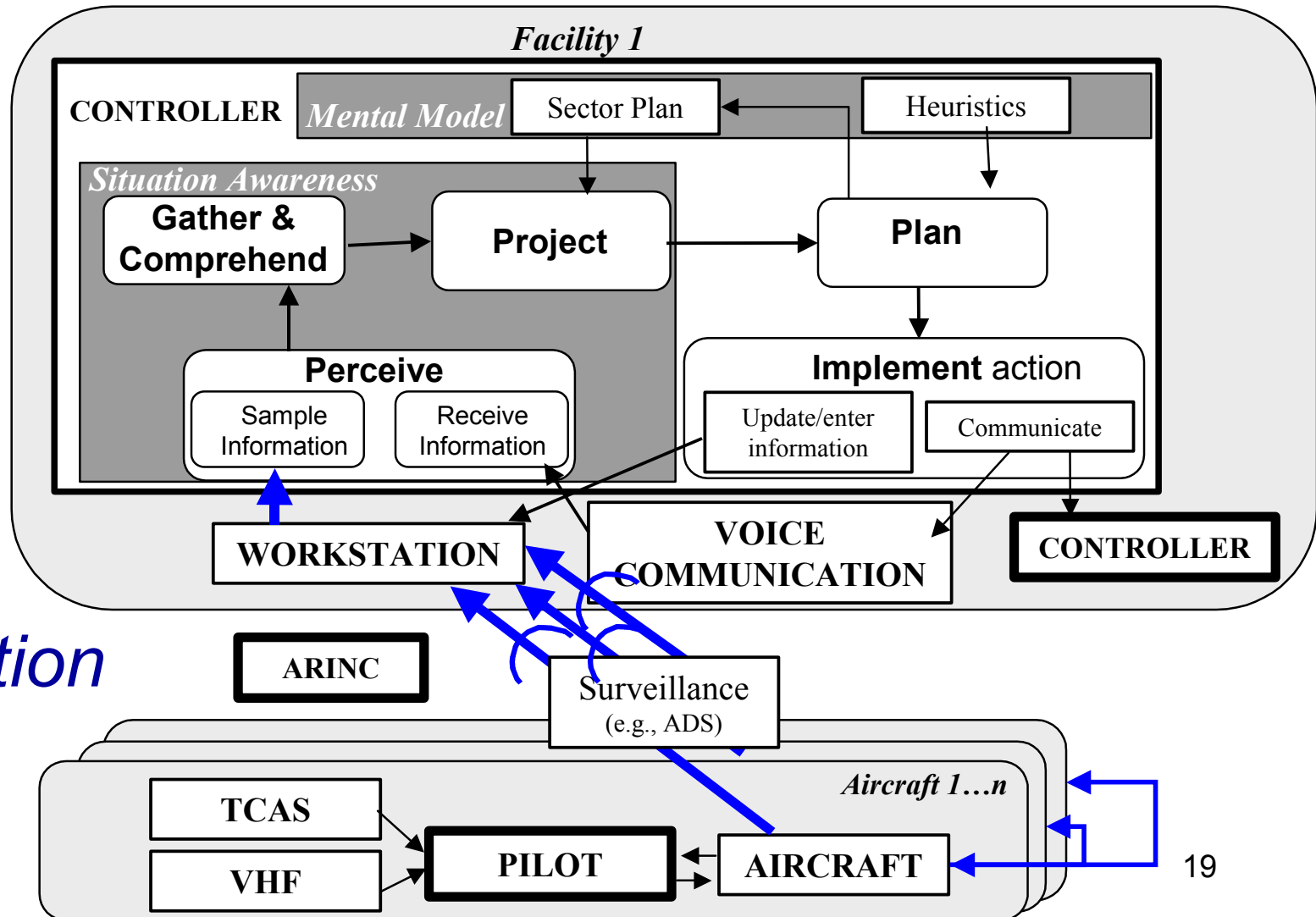
Current & Future Technologies – Oceanic Air Traffic Control Surveillance

- Information accessible by the pilot

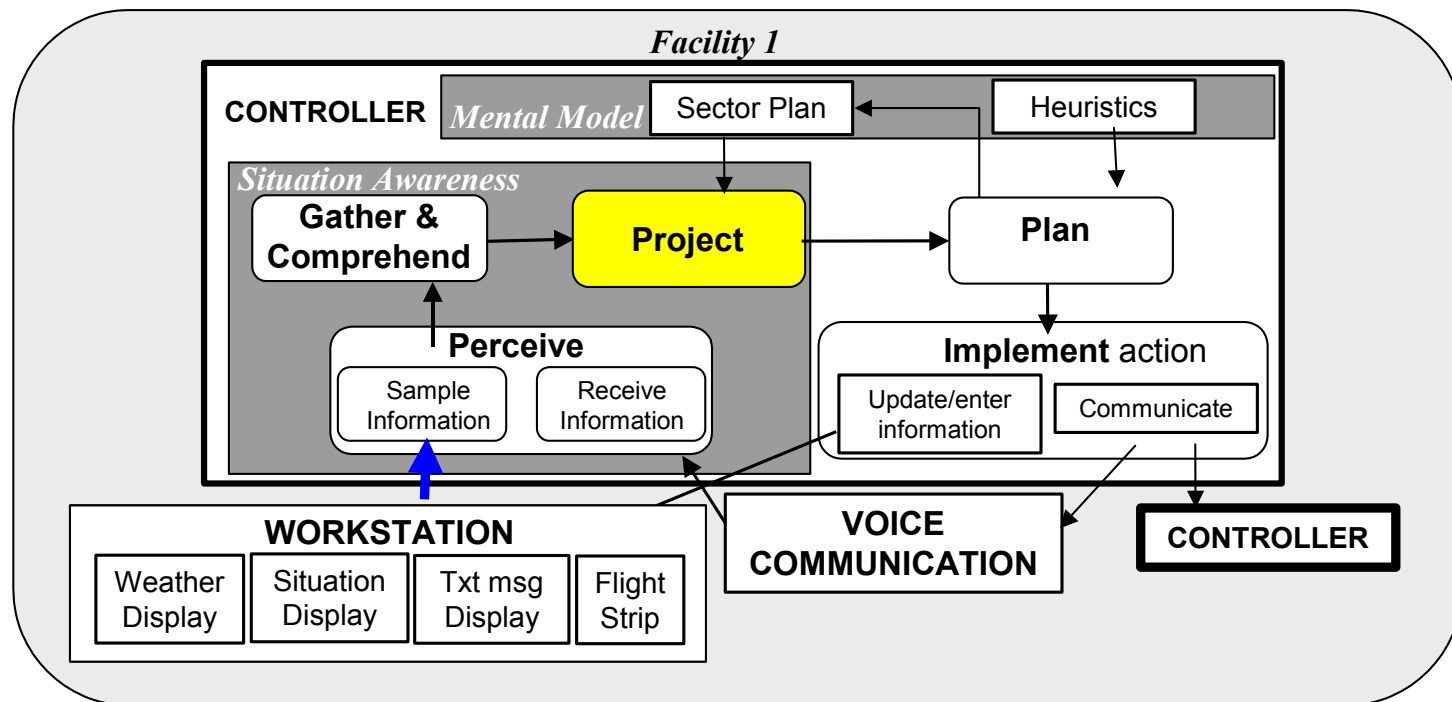


Current & Future Technologies – Oceanic Air Traffic Control Surveillance

- Information accessible by the pilot



Controller's Projection Task



- ❑ Projection Definition: Extrapolation of the system dynamics over a period of interest
- ❑ ATC Projection Task
 - Critical because of its role in conflict prevention
 - Unique due to the controllers' ability to deliver commands that reduce the uncertainty of the future state of the aircraft₂₀



Domestic vs. Oceanic Projection

□ Domestic

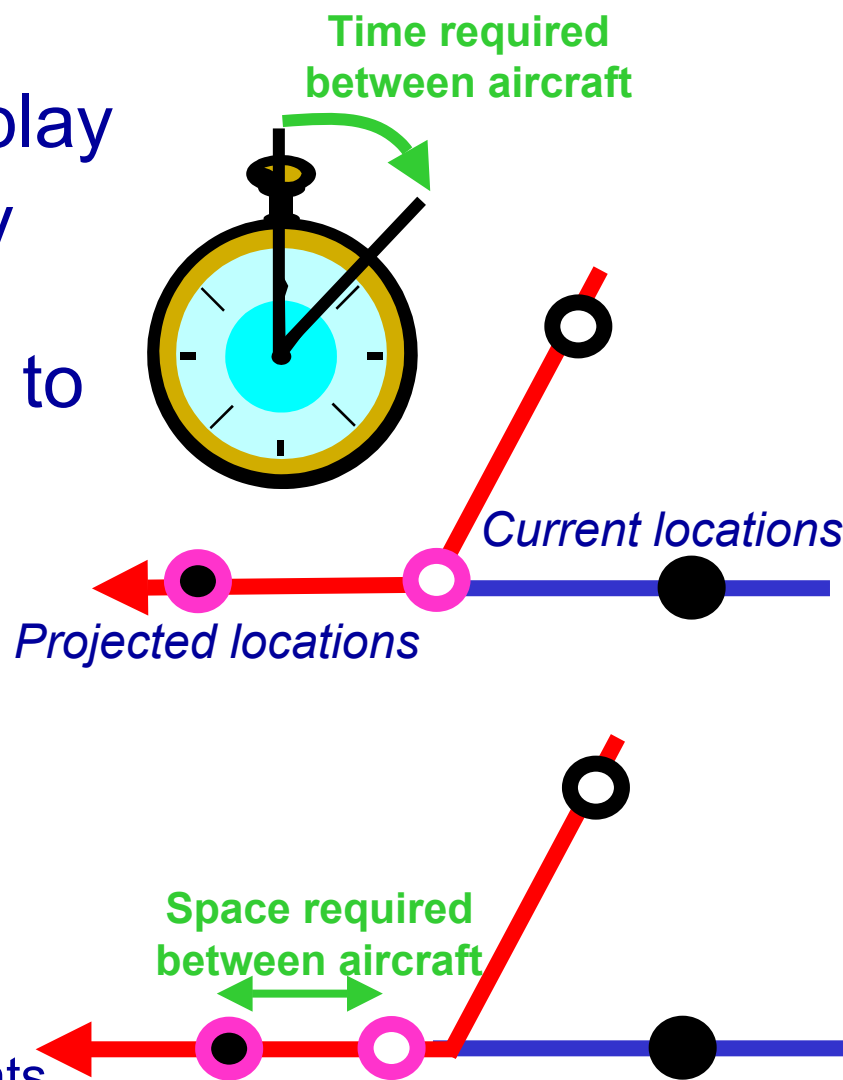
- Spatial projection (mostly perceptual training)
- Command/Surveillance loop quick
- Interface aid: 5 mi rings on the radar screen in TRACON

□ Oceanic

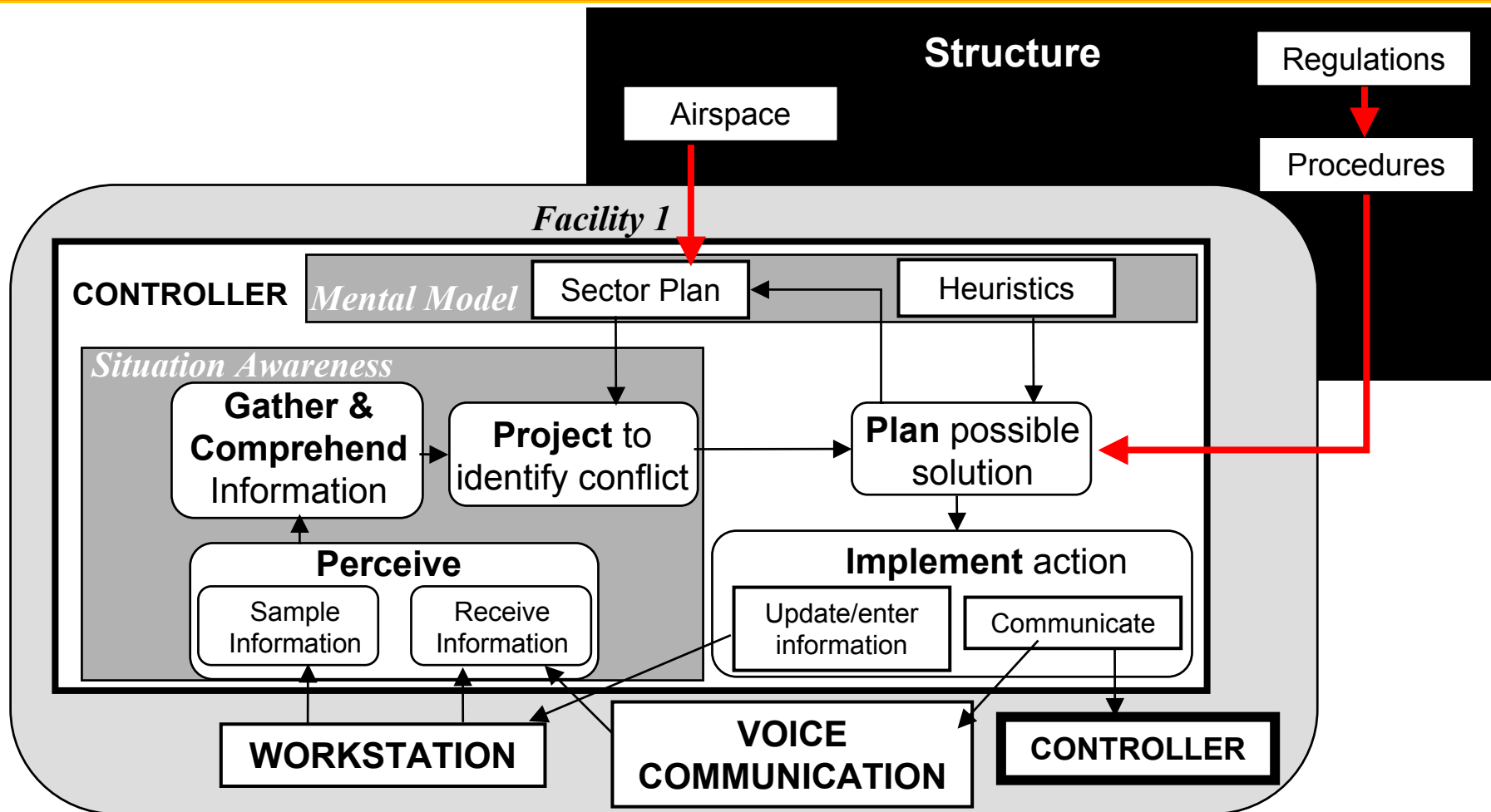
- Mostly time-based projection, in the process of trying to understand this cognitive process for oceanic
- Command/Surveillance loop slow
- Procedural aids
 - Head-on conflict: plotting locations and expected trajectory with grease pencil on erasable map to determine whether additional means of separation besides altitude needed
 - In-trail conflict: phasing time of arrival at position report points

Types of Projection

- ❑ ADS enables radar-quality updates on the situation display
- ❑ High-quality situation display encourages change in procedures from time-based to spatial-based separation
- ❑ Innately different mental computation used in the two types of projection:
 - Time-based projection (Non-surveillance oceanic separation requirements, Minutes-in-trail req.)
 - Spatial-based projection (Surveillance separation requirements, Miles-in-trail requirements,)



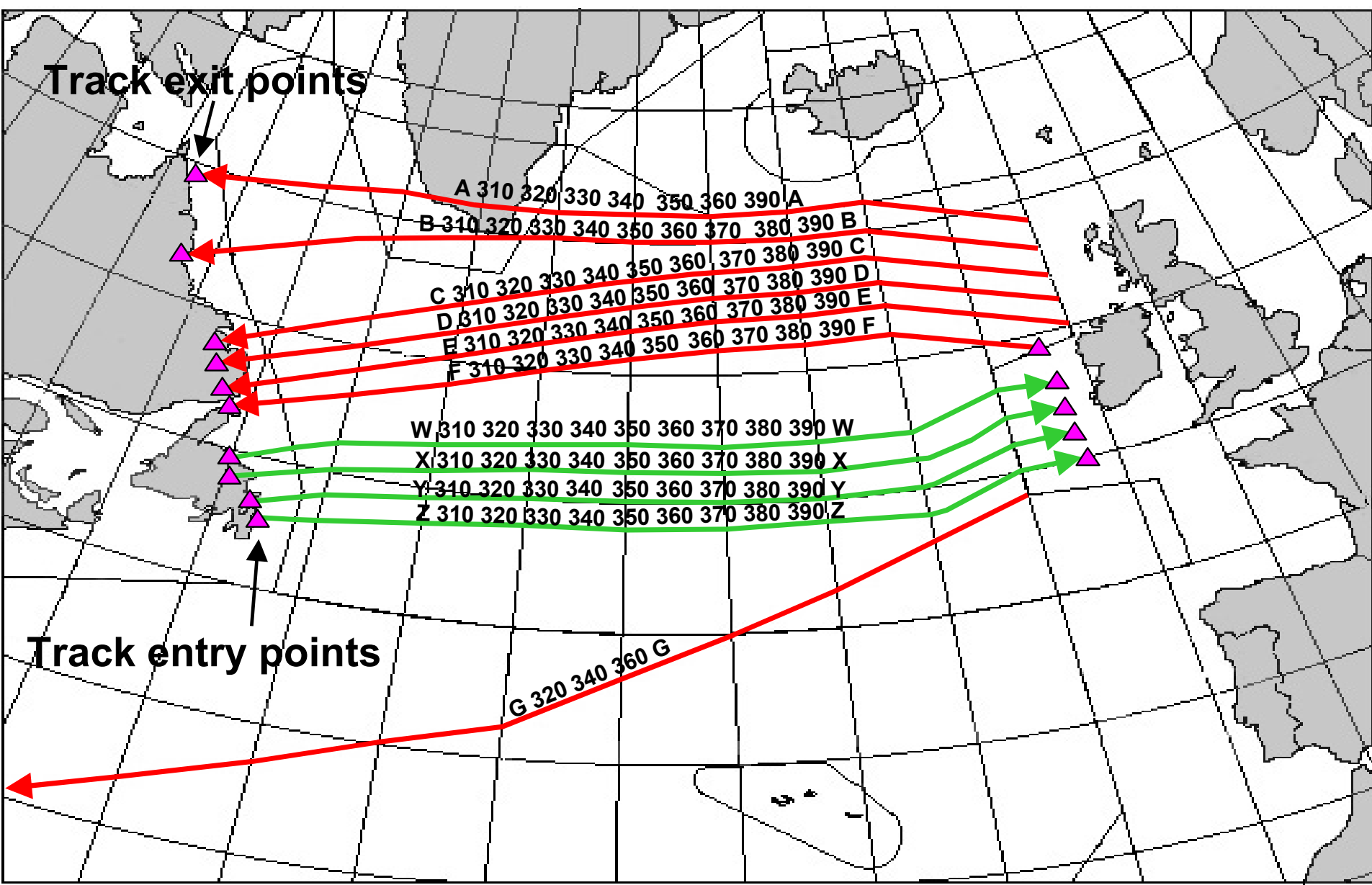
Structure



- ❑ Need to understand the influence of structure
- ❑ How the change in procedures due to the introduction of ADS will change the structure

- ❑ Constraints influence type of projection used:
 - NAT Oceanic: 60 nm lateral separation, 1000 ft vertical separation (RVSM), 10 minutes in trail
 - Separation assurance over oceans provided solely by flight strips (not situation display) in New York
- ❑ Structural aids to cognitive tasks
 - Standard Flow abstraction
 - North Atlantic Tracks System: provides lateral template with minimum 60nm between each track
 - Grouping abstraction
 - Flight Strip Bay organized by lateral, then time, then vertical
 - Critical points abstraction
 - Entry & exit points onto and off tracks
 - Position report points

North Atlantic Tracks





- ❑ In an ADS supported environment the information is fed directly into the workstation which
 - *Pulls the controller out of the loop possibly negatively affecting Situation Awareness.*
 - *Makes the commercial operator redundant.*
- ❑ By using an integrated Oceanic Air Traffic Control Workstation which includes and displays all relevant information to the controller the
 - *Workstation can better support the controller e.g. by conflict probing.*
- ❑ *Providing ADS information could innately change the projection task of the controller from a time-based projection to a spatial-based projection, so*
 - *Consideration should be given to the type (spatial or time) of separation requirements given to the controller in the future and what decision support tools best support the type of projection required*

- ❑ Structure-based abstractions (standard flows, grouping, critical points) play a role in managing the complexity of the oceanic airspace given the current limitations in surveillance, thus
 - Understanding of the benefits of structure-based abstractions in the current environment would aid in understanding the underlying cognitive processes of the controller
 - Consideration could be given to need for development and training of new abstractions to cope with the future environment

- With more information about the traffic within their airspace, pilots will be better able to decide where to move within the airspace (user preferred routing, free flight) which
 - In the near term:
 - *Raises authority issues.*
 - *Causes concern in a mixed equipage environment.*
 - *In the far term*
 - *Provides opportunities for aircraft self-separation.*

Next steps

- ❑ Gather more detailed information on Oceanic Air Traffic Control by site visits, for further development of the model.
- ❑ Do a comparative analysis of the oceanic facilities
 - Investigate the US vs Icelandic procedures
 - NAT/PAC
- ❑ Facilitate integration with the new US oceanic system with other newly developed systems
 - FAA Tech Center ATOP tests
 - Lockheed
 - Site visits

References

- ❑ Hansman, R.J., Kuchar, J.K., Clarke, J.-P., Vakil, S., Barhydt, R., and Pritchett, A. (1997). *Integrated Human Centered Systems Approach to the Development of Advanced Air Traffic Management Systems* <http://atm-seminar-seminar-97.eurocontrol.fr/hansman.htm>
- ❑ Reynolds, T.G., Histon, J.M., Davison, H.J., and Hansman, R.J. (2002). *Structure, Intent and Conformance Monitoring in ATC*. Air Traffic Management Management Research Conference 2002, Capri, Italy.
- ❑ Hansman, R.J. (2002). *Human Factors Considerations In Future Oceanic Air Transportation System Architectures Which Include Automatic Dependant Surveillance*. (Amended 4/5/02). Unpublished research proposal.